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Psychological and attentional outcomes following acute mindfulness induction among high anxiety individuals: A systematic review and meta-analysis

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ABSTRACT

Background: Training outcomes of mindfulness interventions for anxiety have been extensively researched. Less is known about the acute effects of mindfulness induction and associated mechanisms. This systematic review aimed to identify 1) the effect of mindfulness induction on pre-post measures of state anxiety and attention among adults experiencing high levels of anxiety; and 2) the impact of predictors, mediators and moderators on post-induction changes in anxiety and attention. State distress and mindfulness were included as secondary outcomes.

Methods: A systematic search was conducted in November 2021 in electronic databases using relevant search terms. Five studies (four randomised controlled trials and one non-randomised controlled trial) were included, comprising a total of 277 participants with elevated trait/generalised anxiety. Each study used a brief audio-based mindfulness induction exercise.

Results: The meta-analysis indicated mindfulness induction had medium and large effects on state anxiety ($k = 3$, $n = 100$, $g = -0.60$, 95%*CI* [-1.04, −0.16]; $p = .008$) and state mindfulness ($k = 2$, $n = 110$, $g = 0.91$, 95%*CI* [0.52, 1.30], $p < .001$), respectively, when compared with non-therapeutic control conditions. Furthermore, two studies showed small and moderate effects of mindfulness on state anxiety when compared to therapeutic active controls, but were not pooled in a meta-analysis. While results could not be pooled for attention, there was limited evidence of behavioural improvements on tasks measuring aspects of attention following mindfulness induction. However, one study found an increase in Low Beta to High Beta ratio and a reduction in Beta activity in the Anterior Cingulate Cortex following mindfulness induction. Moreover, another study found aspects of state mindfulness mediated reductions in state anxiety.

Limitations: A small number of studies were included in the review, with high risk of bias and low certainty of evidence present.

Conclusion: The findings support the use of mindfulness induction to reduce state anxiety in anxious individuals but suggest gains in state mindfulness may be a more realistic expected outcome. Further controlled trials are needed to delineate the relative effects of objectively assessed anxiety outcomes from mindfulness induction in clinically defined samples.

Mindfulness refers to the practice of consciously attending to the present moment without judgement (Kabat-Zinn, 1994; Tang et al., 2015). Mindfulness-based interventions have been shown to reduce symptoms of anxiety (e.g., Blanck et al., 2018; Haller et al., 2021). These interventions offer an alternative to standard first-line behavioural treatment (i.e., Cognitive Behavioural Therapy [CBT]; NICE, 2020), which may not be accessible by, or well suited to, some individuals (Gunter and Whittal, 2010; Wolitzky-Taylor et al., 2018). Anxiety disorders are the most prevalent mental health condition and are associated with high economic and health care costs, as well as personal costs due to the accompanying impairments to everyday functioning (Bandelow and Michaelis, 2015). Population-based studies indicate that up to

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one-third of individuals will experience an anxiety disorder such as generalised anxiety disorder (GAD; characterised by tendencies to experience worry, fear, and tension in multiple areas of life; APA, 2013) in their lifetime (Bandelow and Michaelis, 2015). However, sub-clinical levels of GAD symptoms are pervasive with double the number estimated to be experiencing these symptoms, compared to clinically-defined GAD (Haller et al., 2014). While research has tended to focus on the longer-term, training effects of mindfulness-based interventions, there is a lack of clear evidence explaining the acute effects of single mindfulness exercises on anxiety symptoms.

Mindfulness induction has been defined as the engagement in a single, brief episode of mindfulness practice to produce a temporary mindful state (Gill et al., 2020). While Schumer et al. (2018) examined the effects of brief, single session mindfulness interventions on measures of negative affect (e.g., state mood, anxiety, emotional distress), this was among various clinical samples (e.g., depression, phobia) as well as non-clinically defined samples. Another review examined the effect of single session yoga, involving mindful focus over bodily movement, on state anxiety in healthy participants (Yin et al., 2021). Both the reviews of Schumer et al. and Yin et al. found small effects, suggesting some reduction in negative affect and anxiety following mindful-related induction. More recent trials including samples not defined by psychological symptoms have also found reductions in state anxiety following mindfulness induction (e.g., Miller et al., 2021), while others have shown no differences between mindfulness induction and control (e.g., relaxation induction, sitting quietly) (Nien et al., 2023). Induction of a mindful state and alleviation of state anxiety and distress is likely to be important for individuals experiencing high levels of anxiety symptoms, characterised by regular experiences of state worry and fear that cause distress and disrupt functioning in day-to-day life (APA, 2013). These samples are more likely to experience repetitive negative thinking (Spinhoven et al., 2018), which mindfulness practice may effectively target (Sommerhoff et al., 2023). Furthermore, while perceived control, self-regulation and behavioural engagement may be involved in longer-term outcomes (e.g., Crandall et al., 2019; Hölzel et al., 2011; Roncoroni et al., 2019; Tang et al., 2015), the experience of acute symptom reduction through use of mindfulness induction may be important in influencing these factors. To date, prior reviews have not systematically examined the acute effects of mindfulness induction exercises in populations defined by high levels of anxiety. Nor have they explored potential mechanisms or individual differences that may vary acute effects. This knowledge is crucial for the development of effective brief mindfulness interventions for anxiety management.

A number of systematic reviews and meta-analyses have concluded that mindfulness-based training interventions involving multiple sessions over a specified time are effective in reducing both clinical and sub-clinical levels of anxiety symptoms (e.g., Blanck et al., 2018; Haller et al., 2021; Vøllestad et al., 2012). Furthermore, previous reviews have examined mediators and moderators of psychological outcomes following mindfulness training interventions (e.g., Alsubaie et al., 2017; Gu et al., 2015; Johannsen et al., 2022; Vøllestad et al., 2012). While trait mindfulness (i.e., general mindful ability) has been consistently identified as a mediator of clinical outcomes following mindfulness training (Alsubaie et al., 2017; Gu et al., 2015; Johannsen et al., 2022), these publications have reviewed studies with mixed anxiety disorders or non-specified samples, and have largely involved 8-week manualised programs (e.g., Mindfulness-Based Cognitive Therapy, Mindfulness-Based Stress Reduction). The effects of psychological induction exercises can be assessed by various measures of autonomic arousal as indices of physiological symptoms of anxiety, including heart rate, respiratory rate, and heart rate variability (i.e., variation in time between successive heart beats) (e.g., Balban et al., 2023; Bortolla et al., 2022), and skin conductance response (i.e., small amounts of sweat measured from fingertips) (e.g., Zangri et al., 2022). To date, findings from these studies and reviews have been mixed (e.g., Zangri et al., 2022) and have included non-clinical participants or samples with mixed clinical presentations. Thus, current knowledge about the effects of mindfulness on anxiety, and relevant mechanisms, mainly relate to training interventions or populations not specifically defined by high levels of anxiety.

Attention has been proposed as a key mechanism involved in mindfulness (Hölzel et al., 2011; Tang et al., 2015). Improvements in attentional control, emotion regulation, and self-awareness are thought to underpin gains in self-regulation following mindfulness practice (Tang et al., 2015; Hölzel et al., 2011). Although findings have been mixed, there is evidence of attentional gains using behavioural tasks following mindfulness training interventions in non-anxious populations (Chiesa et al., 2011; Lao et al., 2016; Yakobi et al., 2021). However, compared to active control conditions, Gill et al. (2020) found no effect of mindfulness induction on measures of attention or executive functioning among non-specified samples in a meta-analysis. More recent trials with non-clinical samples have indicated some gains in inhibition and task shifting abilities following mindfulness induction, yet mixed effects with regards to gains in sustained attention (Somaraju et al., 2023; Ueberholz and Fiocco, 2022; Vieth and Von Stockhausen, 2022). However, prior reviews have not specifically examined samples with high levels of anxiety (Chiesa et al., 2011; Gill et al., Lao et al., 2016; Yakobi et al., 2021). Indices of attentional processes can also be assessed through a number of neurocognitive measures, including electroencephalography (EEG; electrical activity in the brain), event-related potentials (ERPs; brain activity time-locked to stimuli), and functional magnetic resonance imaging (fMRI; blood flow changes occurring with brain activity) (e.g., Bigliassi et al., 2022; Ganesan et al., 2022; Osborn et al., 2022). For example, focused attention meditation (e.g., sustaining attentional focus on a stimulus while disengaging from distraction) has been found to recruit brain regions involved in attention, including the posterior cingulate cortex, anterior cingulate cortex, medial prefrontal cortex, dorsal lateral prefrontal cortex and insula (Ganesan et al., 2022). Furthermore, mindfulness-based induction combined with exercise has been associated with greater beta activity in frontal regions (Bigliassi et al., 2022), while other work has found no differences between brief mindfulness and relaxation practice on EEG band activity (Nien et al., 2023). To date, evidence of attentional improvements using various measures appears inconclusive and, to date, no review has examined this in anxious populations specifically.

According to attentional control theory, individuals with high levels of anxiety have increased automatic attentional processing (e.g., orienting attention to threat) and decreased voluntary processing (e.g., executive control over attention) in response to threat (Eysenck et al., 2007). This is thought to produce *attentional biases to threat* relative to neutral stimuli, which has been demonstrated extensively in cognitive reaction time tasks (Bar-Haim et al., 2007; Eysenck et al., 2007). To date, while studies have examined attentional outcomes of mindfulness induction in anxious individuals, no study has systematically reviewed such findings. This is of interest to investigate as there is overlap between the attentional processes proposed to be trained through mindfulness practice (e.g., Yakobi et al., 2021) and disrupted in anxiety (e.g., Eysenck et al., 2007). Thus, there is a need for greater knowledge regarding the role of attention in mindfulness outcomes among anxious populations who are in greater need of intervention for symptom reduction and who may be more vulnerable to disruptions in attentional processing.

The current review aimed to address gaps in the existing literature to understand the effects, and associated mechanisms, of mindfulness induction in anxious individuals. This review focused on samples experiencing both clinical and sub-clinical levels of general or generalised anxiety symptoms specifically, to minimise variation in symptomatology. The outcomes reviewed included state anxiety and attention (primary outcomes), as well as state mindfulness and other state measures of mood or distress (treated as secondary outcomes). We also sought to review previous findings of both individual (e.g., personality, cognitive, biological measures) and interventional (e.g., dosage)

predictors, mediators, and moderators, as well as conduct our own meta-analyses exploring the relationship between other predictors and our primary outcomes. This review therefore sought to inform future research and practice aimed at optimising acute mindfulness induction for anxious individuals.

1. Objectives

The current systematic review and meta-analysis aimed to address the following questions:

1. What is the effect of acute mindfulness induction on pre-post measures of state anxiety and attention compared to control exercises/conditions in individuals with high levels of anxiety?
2. What is the impact of predictors, mediators and moderators on pre-post reductions in state anxiety and improvements in attention following acute mindfulness induction in individuals with high levels of anxiety?

2. Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and Cochrane recommendations (Higgins et al., 2022). A protocol was pre-registered at PROSPERO (CRD42021222389). The current review was conducted as part of a broader review also looking at the effect of mindfulness training interventions (see Williams et al., 2023). Only studies involving acute induction interventions were included in the current review. Aside from differences in eligibility criteria, the methods employed for the current review are consistent across the two studies, and complete details regarding data search, extraction, and analysis procedures are reported in Williams et al.

3. Eligibility criteria

3.1. Population

Adult participants assessed as having high levels of general, generalised or trait anxiety on validated self-report measures or a formal diagnosis of GAD were included in this review. Participants needed to be aged 17 and 70 years to be included. The lower limit of 17 years was chosen to account for student samples where a majority of students may be defined as adults (≥18 years), while the upper limit of 70 years was chosen to screen out older participants who are likely possess differences in terms of health and lifestyle. Studies involving participants selected on the basis of another sub-type of anxiety (e.g., social anxiety disorder) or psychological disorder (e.g., depression) were excluded. Studies were also excluded if they involved participants selected on the basis of recent or current pregnancy or a current or previous medical, developmental, or neuropsychological condition, including cognitive impairment.

3.2. Intervention/comparator

Included studies needed to have employed a single-session mindfulness induction intervention. Interventions were included if they involved practising at least some of the key characteristics referred to in Kabat-Zinn's (1994, p. 4) definition of mindfulness: "paying attention … on purpose, in the present moment, and non-judgementally". We excluded induction exercises that largely comprised of other therapeutic components that did not specifically or primarily involve mindfulness (e.g., relaxation, problem solving, yoga). Multi-session training or manualised interventions (e.g., Mindfulness-Based Stress Reduction) were also not included. Studies with a waitlist, active, or alternative treatment control or another comparison were included. Studies were excluded if they exclusively used another mindfulness induction exercise as a comparison.

3.3. Outcomes

Included studies needed to have at least one state anxiety or attention outcome (i.e., primary outcomes) that was measured at both pre- and post-induction. Anxiety-related outcomes could include self-report (i.e., state anxiety), biological (e.g., functional magnetic resonance imaging [fMRI] for amygdala activation, cortisol), or physiological (e.g., skin conductance response, heart rate) measures. Attention-related outcomes could include behavioural (e.g., reaction time, accuracy), clinician-rated assessment, electroencephalography (EEG), event-related potentials (ERP), or fMRI measures of attention processes (e.g., orienting, executive control, inhibitory control, attentional bias to threat). These methods of measurement are standard within the fields of anxiety and attention research and were selected to examine a range of mechanisms across numerous disciplines (e.g., Balban et al., 2023; Bigliassi et al., 2022; Bortolla et al., 2022; Ganesan et al., 2022; Gill et al., 2020; Lao et al., 2016; Osborn et al., 2022; Yakobi et al., 2021; Zangri et al., 2022).

3.4. Study design and characteristics

Date limits were not imposed and studies were also excluded if they were not a full text study article, written in English, or published in a peer-reviewed journal.

4. Information sources and search strategy

We searched three databases (Web of Science, Scopus, PsycINFO via Ovid), with the last search conducted on November 25, 2021. We also reviewed citations in studies included in the current review and from recent related meta-analyses and systematic reviews. The full search strategy (see Supplementary Materials, Table S1) was developed in consultation with an independent research Librarian at the University of Tasmania and was tested, revised, and reviewed by MW.

5. Selection process

Title/abstract and full-text screening was undertaken by the reviewers using Covidence (Veritas Health Innovation, 2022). Duplicates were first removed. All titles/abstracts and full-text studies were screened by MW and independent screening was divided between AM, SS and BS. Disagreements between reviewers were discussed until a consensus was reached and, if necessary, a senior author (AM) was consulted for final decisions.

6. Data collection process

MW extracted all data for included studies using a data extraction form. The form was initially piloted by MW and reviewed by a senior author (AM). AM was consulted when there were uncertainties regarding data needed for extraction. Attempts were made to contact study authors where information was missing or unclear. Journal titles, study authors and institutions were not blinded during extraction.

7. Data items

Information was extracted regarding the study article, participants, intervention and control groups, outcomes, and research design. In addition to primary outcomes (state anxiety and attention), we also extracted data from self-report measures of state mindfulness and state mood or distress. For each study outcome, we extracted the data needed to compute standardised effect sizes for pre-post induction for both the intervention and control/comparison group in each study. Where more than one measure of state mindfulness (i.e., in accordance with

Kabat-Zinn's 1994 definition) was included in a study, the measure most aligning with present-moment awareness or the reverse (i.e., mind-wandering or task/stimulus unrelated thinking) was selected. Where reported data compatible with an outcome domain was insufficient for pooling (i.e., less than two studies reporting same outcome measure), key findings, as defined by the study authors with respect to their hypotheses, were obtained for inclusion in the narrative review. Additionally, where regression, mediation or moderation was undertaken with anxiety or attention outcome measures, we extracted key findings, as defined by the study authors with respect to their hypotheses, for inclusion in the narrative review.

8. Study risk of bias assessment

The revised Cochrane 'Risk of bias' (RoB) tool for randomised trials (RoB 2.0) (Sterne et al., 2019) was used for randomised controlled trials. RoB 2.0 addresses five sources of bias that arise from: (1) the randomisation process; (2) deviations from intended interventions; (3) missing outcome data; (4) measurement of the outcome; and (5) selection of the reported result. For each of these domains, a RoB judgment was made: low; some concerns; high. The Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) assessment tool (Sterne et al., 2016) was used for non-randomised controlled trials. ROBINS-I addresses seven sources of bias including that arising from: (1) confounding; (2) selection of participants; (3) classification of interventions; (4) deviations from intended intervention; (5) missing data; (6) measurement of outcomes; and (7) selection of the reported result. For each domain, a RoB judgment was made: low; moderate; serious; critical. An overall summary RoB judgement was derived for each specific outcome. The overall RoB for each study was determined by the highest RoB level in any one domain. However, where RoB was assessed as high for the 'measurement of the outcome' domain due to inclusion of a self-report measure and a non-blinded intervention, we chose to override the default judgement of overall high RoB. While self-report measures carry greater risk of bias when a participant knows their assigned intervention, these measures are the most common and rigorous measures used in clinical trials for anxiety symptoms. Furthermore, blinding a participant to a behavioural intervention to mitigate bias is often not possible, as participants actively engage in the exercises for their intervention (e.g., mindfulness, relaxation). Therefore, given these contextual factors, we have decided not to reflect this in the overall RoB judgement for the included studies. However, for transparency, we have still reported high RoB for this domain where it has applied. MW applied the appropriate tool to each reported outcome in each included study. Where uncertainties arose, a senior author (AM) was consulted. Where information was missing or unclear, attempts were made to contact corresponding authors.

9. Data synthesis methods

9.1. Overall analyses

For objective 1 (i.e., pre-post effects of induction), standardised mean difference (SMD) effect sizes (Hedge's *g*) between the mindfulness and control interventions were calculated with 95% confidence intervals. A negative SMD indicated greater effect of the treatment compared to control condition for state anxiety and state distress outcomes, while a positive SMD indicated greater effect of treatment for the state mindfulness outcome. The effect sizes of SMDs were interpreted as 0.20 = small, 0.50 = moderate, 0.80 = large (Cohen, 1992). Pre-post change means and change standard deviations of each intervention condition were used to calculate SMDs. Where change deviations from a study were not reported these were either calculated from other available statistics or imputed, using methods described in the Cochrane Handbook (Higgins et al., 2022).

Pairwise meta-analyses with restricted maximum-likelihood were conducted when at least two studies reported the same outcome measured at pre- and post-intervention. Random-effects models were chosen to calculate the average distribution of treatment effects (Higgins et al., 2022). Meta-analyses were undertaken using the *metan* package in StataSE 17 statistical software (StataCorp, 2021).

Where more than one comparison group was used in a study, we selected the comparison condition that was most similar to most other studies eligible for inclusion in the meta-analysis (i.e., non-therapeutic controls). Relevant effects that were not eligible for inclusion in a meta-analysis (i.e., less than two studies with the same outcome measure) were reported as part of the narrative review. For the narrative review, summary statistics and effect estimates were reported where sufficient data was available. Effect sizes for bivariate correlations associated with any reported regression/mediation analyses were interpreted as.10 = small, 0.30 = moderate, 0.50 = large (Cohen, 1988).

To address Objective 2, we sought to examine the relationship between other predictor variables with our primary outcomes using meta-regression. However, the number of included studies containing data for the same predictor and outcome measures were too low to warrant meta-regression (i.e., less than 10; Higgins et al., 2022). Thus, only findings from previous correlation, regression, moderation, and mediation analyses were reported in the narrative review.

9.2. Statistical heterogeneity

The I^2 statistic (proportion of between-study heterogeneity) and *Q*-statistic (whether between-study heterogeneity was greater than expected by chance) were reported as measures of between-study heterogeneity. The T^2 statistic and 95% *CI*s (uncertainty intervals) were also reported as a measure of the variance of effect sizes. The magnitude of heterogeneity was categorised according to the following cut-offs: I^2>30% = moderate, I^2>50% = substantial, I^2 >75% = considerable (Higgins et al., 2003, 2022). Evidence for heterogeneity was also judged through localisation on the forest plot. While we intended to perform sub-group analyses to explore sources of high levels of heterogeneity (e.g., according to participant, intervention, and control characteristics), the number of studies were too low to perform these (i.e., less than 10 studies; Higgins et al., 2022). Where high levels of heterogeneity were identified (≥50% or $p < .05$), sensitivity analyses were performed. This included removal of clear outliers, as visually inspected on forests plots.

9.3. Bias assessment

We planned to visually inspect funnel plots and conduct Egger's test to assess publication bias. However, the number of studies in a given meta-analysis were too low to warrant these (i.e., less than 10; Egger et al., 1997; Higgins et al., 2022).

9.4. Certainty assessment

The quality of evidence for all outcomes was evaluated using the Grading of Recommendations Assessment, Development and Evaluation method (The GRADE Working Group, 2022)by MW across the domains of risk of bias, inconsistency, indirectness, imprecision, and publication bias. The certainty of evidence was assessed as high, moderate, low, or very low. We followed methods and recommendations described in the Cochrane Handbook (Higgins et al., 2022) and by The GRADE Working Group (2022).

10. Results

10.1. Study selection

See Fig. 1 for a PRISMA flow chart showing the record selection process. We found 12,936 records in databases using our search strategy. After initial automated duplicate removal in Covidence, 8905 records were screened, from which 669 full-text documents were reviewed.

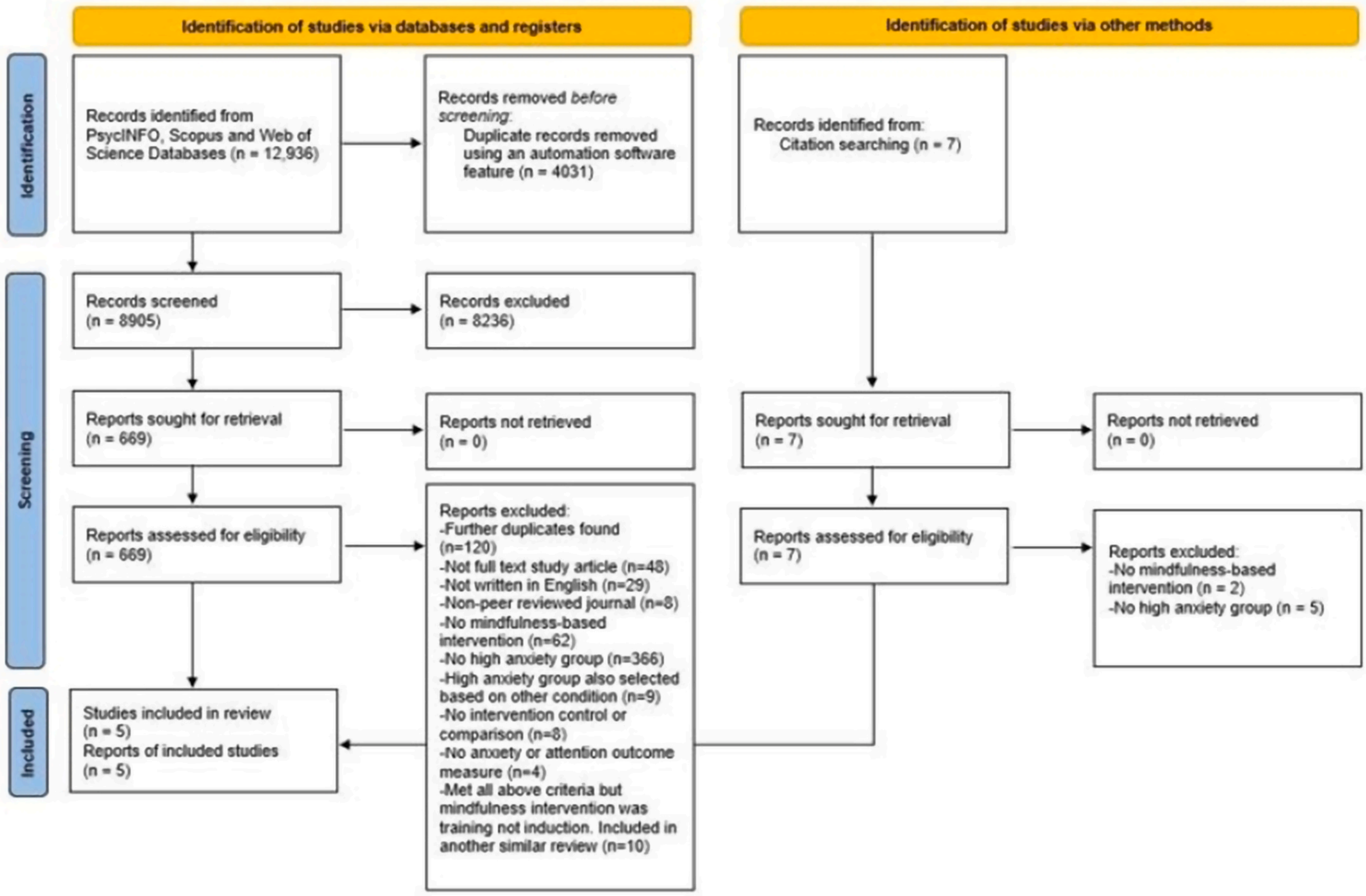

Fig. 1. Prisma flow chart of the study selection process.

Finally, five papers were included [Lee and Orsillo, 2014; McEvoy et al., 2017; Tarrant et al., 2018; Wadsworth and Hayes-Skelton, 2020; Xu et al., 2017]. Later, we searched the references of the initially included studies, as well as 11 systematic reviews/meta-analyses of mindfulness interventions that were published in the last 10 years. However, no extra articles fulfilled the inclusion criteria. An article by Knight and Emery (2021) was initially included but later excluded due to lack of a pre-intervention outcome measure.

10.2. Study characteristics

The five included studies (see Table 1) were published between 2014 and 2020 and included a total of 277 participants with a median age of 24.09 and a median of 77% females. All studies investigated participants who met cut-off criteria to indicate high anxiety on self-reported measures of trait anxiety or general/generalised anxiety symptoms. All studies included an audio-based mindfulness induction exercise delivered in a laboratory setting, with dosage ranging from 4 to 20 min (see Table 2). Five studies included a control exercise of a non-therapeutic nature (i.e., thought wandering, eyes open resting, listening to a book or news article), while two included a control exercise of a therapeutic nature (relaxation, attention training).

10.3. Risk of bias in studies

Four of five of the included studies were RCTs and were therefore assessed using the RoB 2.0 tool (see Fig. 2). In terms of overall RoB, two studies were assessed as having a high risk of bias, for each outcome. RoB was assessed as high for the 'measurement of the outcome' domain for each study for the outcomes state anxiety, state mindfulness and state distress as these involved self-report tools where ratings are considered susceptible to the influence of a behavioural intervention intended to improve mental health. However, where RoB was assessed as high for the 'measurement of the outcome' domain, we chose to override the default judgement of overall high RoB on this basis alone, as self-report measures are common to the field and behavioural interventions are often not possible to blind participants to (see methods section). Three out of four studies clearly reported a random allocation sequence and two out of four studies reported conducting an appropriate intention-to-treat analysis. As we were not able to obtain an a priori analysis plan for any of the studies, 'some concerns' were noted for all four studies for the domain 'selection of the reported results'. Table 3 shows the ROBINS-I RoB assessment for the one non-randomised study (Tarrant et al., 2018). Results were comparable with randomised studies in terms of missing data, measurement of outcomes, and selection of reported results. Confounding due to previous mindfulness experience was judged as expected, but adequately controlled for.

10.4. Results of syntheses

10.4.1. Pre-post effects for self-reported state anxiety

The mean pre-post change in state anxiety was not statistically significant following mindfulness induction exercises compared to non-therapeutic active control exercises (4 trials; $n = 154$; $SMD = -1.79$, 95% CI [-4.04, 0.47], 95% PI [-12.70, 9.13], $p = .120$) (see Supplementary Materials, Fig. S1). There was evidence of considerable heterogeneity ($\chi^2 = 62.16, p < .001, \tau^2 = 5.11, I^2 = 97\%$). However, there was one clear outlier (i.e., McEvoy et al., 2017) that influenced the results. A sensitivity analysis showed that following the removal of this outlier, greater reductions in state anxiety were observed following

Table 1
Characteristics of included studies.

Author	Origin	Sample size (*N*)	Mean age (SD)	Females %	Anxiety characteristics	Mindfulness experience	Conflicts of interest/funding	Design	Timepoints	Anxiety outcomes	Attention outcomes	Secondary outcomes
Lee and Orsillo, 2014	USA	42	29.61 (12.21)	79%	>4.5 GADQ ≥45 PSWQ ≥40 STAI (trait subscale)	Excluded on current mindfulness or meditative practice.	None declared.	RCT	Pre, post	STAI (state subscale)		State mindfulness: MAAS-state
McEvoy et al. (2017)	AUS	81	23.60 (7.66)	80%	≥40 STICSA (trait subscale)	No exclusion on level of experience.	None declared.	RCT	Pre, post	STICSA (state subscale)	Stroop switching task (RTs, accuracy)	State mindfulness: TOA
Tarrant et al. (2018)	USA	26	47.1 (16.1)	77%	≥8 GAD-7	No exclusion on level of experience.	Lead author contracted by StoryUp Virtual Reality. Second author conducted data analysis and interpretation.	Controlled trial	Pre, post	STAI (state subscale)	Resting state EEG for Alpha and Beta sub-bands	
Wadsworth and Hayes-Skelton, 2020	USA	46	24.09 (8.54)	74%	≥25 ADDQ	No exclusion on level of experience.	None declared.	RCT	Pre, post	SUDS		
Xu et al. (2017)	Canada	82	20.0 (1.8)	67%	≥43 STICSA (total)	Excluded on previous meditation experience (amount not specified).	Research Council grant.	RCT	Pre, post		Sustained attention task (RTs)	State mindfulness: % of mind wandering thoughts during sustained attention task. State distress: PANAS (negative affect subscale)

Note. USA = United States of America; GADQ = Generalised Anxiety Disorder Questionnaire-IV; PSWQ = Penn State Worry Questionnaire; STAI = State-Trait Anxiety Inventory; MAAS-state = Mindful Attention Awareness Scale – State Version; AUS = Australia; STICSA = State-Trait Inventory for Cognitive and Somatic Anxiety; RT = reaction time; TOA = Temporal Orientation of Attention; GAD-7 = Generalised Anxiety Disorder-7; EEG = Electroencephalography; ADDQ = Anxiety Disorder Diagnostic Questionnaire; SUDS = Subjective Units of Distress Scale; PANAS = Positive and Negative Affect Schedule.

Table 2
Characteristics of interventions of included studies.

Author	Mindfulness induction exercise	Content of exercise	Delivery	Context	Dosage	Adherence	Control condition
Lee and Orsillo, 2014	Mindfulness of the breath	Directed to focus attention on breath and redirect when notice mind wandering.	Audio recording	Lab	20-mins	MAAS-STATE administered pre-post and taken as a manipulation check by the authors.	A) 20-min thought wandering. "Sit quietly and to think of whatever comes to mind". B) 20-min relaxation. "Sit quietly and enjoy the relaxing music".
McEvoy et al. (2017)	Mindfulness-based Progressive Muscle Relaxation	Directed to pay attention to, and allow change of, bodily sensations during sequential tensing and releasing of muscle groups.	Audio recording	Lab	12-mins	No measure intended to assess adherence.	A) 12-min thought wandering. "Sit quietly and to think of whatever comes to mind". B) 12-min attention training technique. Instructed to shift attention to different sounds.
Tarrant et al. (2018)	Mindfulness in nature experience	Directed to pay attention to elements of a nature scene and imagine they embody the same qualities.	Guided virtual reality with audio	Lab	5-mins	No measure intended to assess adherence.	5-min open eyes resting period.
Wadsworth and Hayes-Skelton, 2020	Acceptance-based exercise	Included information relating to low control and examples of applying acceptance. Instructed to apply acceptance of low controllability and resultant emotions to a lab task.	Audio recording	Lab	4-mins	Participants asked to rate how much they used acceptance skills during a second trial of IGT on a 10- point Likert scale (0 = not at all during the task, 5 = about half the time, 10 = throughout the entire task).	Listening to a 4-min news article audio recording.
Xu et al. (2017)	Mindfulness of body and breath	Directed to focus attention on breathing and remain open-minded to their experience.	Audio recording	Lab	10-mins	No measure intended to assess adherence.	Listening to a 10-min audio book.

Note. MAAS-state = Mindful Attention Awareness Scale – State Version; IGT = Iowa Gambling Task.

mindfulness induction exercises as compared to active control exercises, with medium effect (3 trials; $n = 100$; $SMD = -0.60$, 95% CI [-1.04, −0.16], 95% PI [-4.24, 3.04], $p = .008$) (see Fig. 3). Furthermore, evidence of heterogeneity was no longer observed ($x^2 = 2.32$, $p = .313$, $\tau^2 = 0.03$, $I^2 = 20\%$).

Two RCTs included a second control exercise that was of a therapeutic nature (i.e., attention training, relaxation). Summary statistics and effect estimates are presented in Supplementary Materials, Table S2. Given these two control interventions were distinct and the mindfulness induction exercises also differed in terms of content and dosage for these two studies, we elected to report the two effect estimates separately rather than pool them in a meta-analysis. Lee and Orsillo (2014) reported a statistically significant pre-post reduction in state anxiety for participants randomised to a 20-min mindful breathing exercise ($p = .005$) but not a relaxation exercise (listening to relaxing music) ($p = .051$). The size of the difference in effect between conditions was moderate ($g = 0.52$, 95%CI [-0.21, 1.26]). McEvoy et al. (2017) reported statistically significant pre-post reductions in state anxiety for participants randomised to a 12-min mindful PMR exercise ($p < .001$) and an attention training technique where participants were instructed to shift their attention to various sounds ($p < .001$). The conditions did not differ at post-intervention ($p = .950$) and the size of the difference in effect between conditions was small ($g = 0.18$, 95%CI [-0.34, 0.71]).

10.4.2. Pre-post effects for self-reported state mindfulness

The mean pre-post change in state mindfulness was not statistically significant following mindfulness induction exercises compared to non-therapeutic active control exercises (3 trials; $n = 164$; $SMD = 2.26$, 95% CI [-0.49, 5.00], PI [-32.95, 37.46], $p = .107$) (see Supplementary Materials, Fig. S2). There was evidence of considerable heterogeneity ($x^2 = 50.31$, $p < .001$, $\tau^2 = 5.71$, $I^2 = 98\%$). However, there was one clear outlier (i.e., McEvoy et al., 2017) that influenced results. A sensitivity analysis showed that following the removal of this outlier, significantly greater gains in state mindfulness were observed following mindfulness induction exercises as compared to active control exercises, with large effect (2 trials; $n = 110$; $SMD = 0.91$, 95% CI [0.52, 1.30], PI [00.00, 00.00], $p < .001$) (see Fig. 4). Furthermore, evidence of heterogeneity was no longer observed ($x^2 = 0.12$, $p = .729$, $\tau^2 = 0.00$, $I^2 = 0\%$).

Two RCTs included a second control exercise that was of a therapeutic nature (Lee and Orsillo, 2014; McEvoy et al., 2017). Summary statistics and effect estimates are presented in the Supplementary Materials, Table S2. Lee and Orsillo (2014) did not find statistically significant pre-post differences in self-reported state mindfulness following 20 minutes of mindful breathing ($p = .120$) or listening to relaxing music ($p = .300$). The size of the difference in effect between conditions was small ($g = 0.27$, 95%CI [-0.45, 1.00]). McEvoy et al. (2017) found participants reported significantly greater present-focused attention following both a 12-min mindful PMR exercise ($p = .001$) and attention training technique ($p = .002$). The conditions did not differ at post-intervention ($p = .990$) and the size of the difference in effect between conditions was negligible ($g = 0.01$, 95%CI [-0.51, 0.54]).

10.4.3. Pre-post effects for self-reported state distress

One RCT included a measure of self-reported state distress. Xu et al. (2017) found statistically significant pre-post reductions in state negative affect following a 10-min mindfulness of body and breath exercise ($p < .010$) but not following active control (listening to an audio book) ($p > .050$). The size of the difference in effect between conditions was small ($g = 0.29$, 95%CI [-0.14, 0.72]). Summary statistics and effect estimates are presented in Supplementary Materials, Table S2.

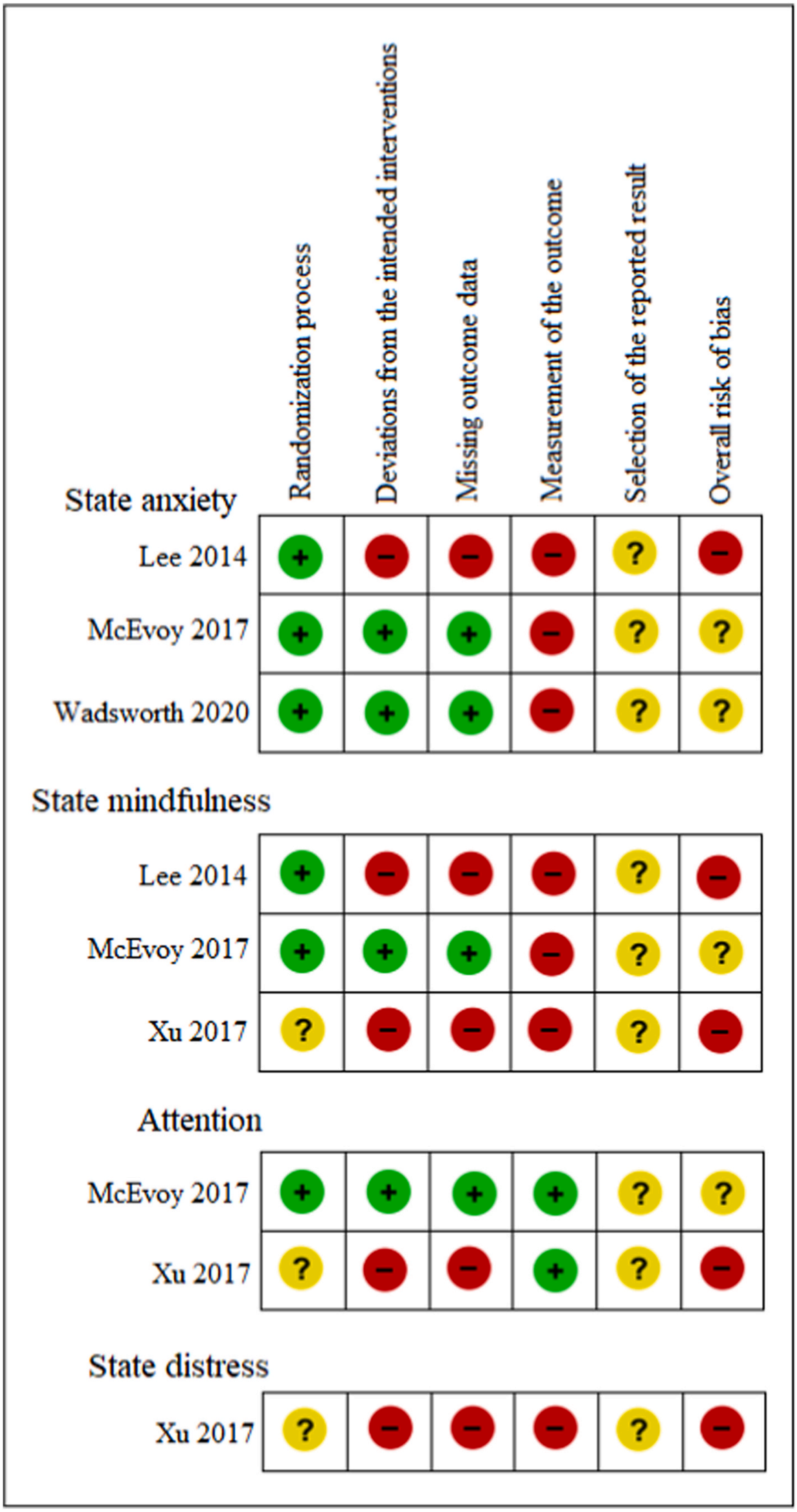

Fig. 2. RoB 2.0 Risk of Bias Summary for Studies included in the Meta-Analysis and Narrative Review for each Outcome.

Table 3
ROBINS-I Risk of Bias Assessment for One Non-Randomised Study included in the Meta-Analysis (State Anxiety) and Narrative Review (Attention).

	Outcome	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Domain 6	Domain 7	Overall
Tarrant et al., 2018	State anxiety (self-report)	Moderate	Low	Low	Low	Moderate	Serious	No information	Moderate
Tarrant et al., 2018	Attention (EEG)	Moderate	Low	Low	Low	Moderate	Low	No information	Moderate

Note. Domain 1 = bias due to confounding; Domain 2 = bias in selection of participants into the study; Domain 3 = bias in classification of interventions; Domain 4 = bias due to deviations from intended interventions; Domain 5 = bias due to missing data; Domain 6 = bias in measurement of outcomes; Domain 7 = bias in selection of the reported result; EEG = Electroencephalography.

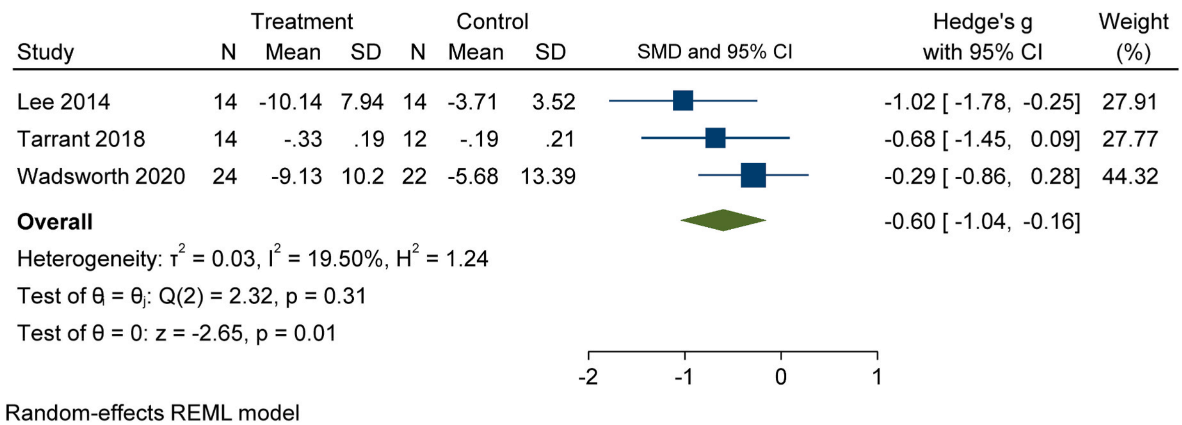

Fig. 3. Forest Plot Showing the Effect of Mindfulness Induction Exercises on State Anxiety as Compared to Active Control Exercises
Note. Forest plot excludes the outlying study that was removed from further analysis.

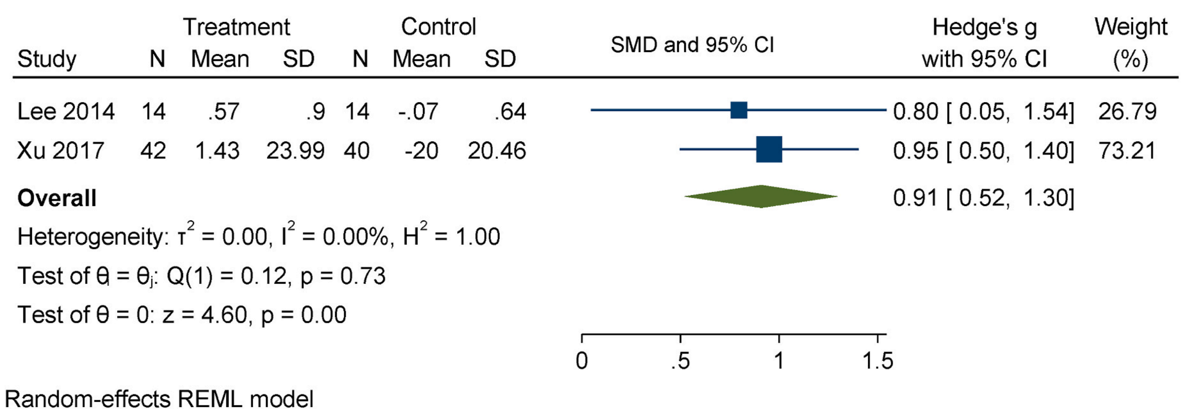

Fig. 4. Forest Plot Showing the Effect of Mindfulness Induction Exercises on State Mindfulness as Compared to Active Control Exercises
Note. Forest plot excludes the outlying study that was removed from further analysis.

10.4.4. Pre-post effects for attention measures

Three studies included at least one attention outcome measure at pre- and post-induction. These could not be pooled in a meta-analysis due to differences in the facets of attention being examined and the instruments used. In an RCT, Xu et al. (2017) used a Metronome Response Task to measure sustained attention where participants responded to a periodic metronome tone. Rhythmic Response Time (RRT) was the difference between the time of key press and tone onset. Higher RRT variance means that responses were less synchronous, indicating poorer performance. RRT variance was calculated for both overall trials, as well as for intervals of trials where participants reported mind wandering when probed. Summary statistics and effect estimates are presented in Supplementary Materials, Table S2. Greater RRT variance overall was found following both a 10-min mindfulness of body and breath exercise ($p < .001$) and an active control (i.e., listening to an audio book) ($p < .010$). No group differences were observed ($p > .050$) and the size of the difference in effect between conditions was negligible ($g = 0.03$, 95%*CI* [-0.40, 0.46]). Furthermore, for only trial intervals where participants reported mind wandering, greater RRT variance was found following both conditions ($p < .001$). Group differences were not statistically significant ($p > .050$). However, the effect size was small-moderate, indicating greater increases in RRT variance (thus poorer performance) following the mindfulness induction condition ($g = 0.46$, 95%*CI* [0.02, 0.89]).

In an RCT, McEvoy et al. (2017) used a modified emotional Stroop switching task as a measure of cognitive flexibility. Participants named the colour of neutral and threat-related words. However, if a box appeared around the word, participants read the word rather than named the colour. Faster pre-post reaction times were found following three separate conditions (i.e., 12-min mindful PMR exercise, attention training technique, thought wandering condition), for both neutral ($p = .021$) and threat ($p = .011$) words. Pre-post change did not differ significantly between groups. Summary statistics and effect estimates for pre-post effects for each condition are provided in Supplementary Materials, Table S3.

In a non-randomised intervention study conducted by Tarrant et al.

(2018), participants' brain activity was measured using EEG. The ratio of Low Beta to High Beta significantly increased (favouring Low Beta power) following a 5-min mindfulness in nature virtual reality exercise ($p = .005$, $g = 0.25$, 95%*CI* [-0.25, 0.75]) but not an open eyes resting period ($p = .463$, $g = 0.05$, 95%*CI* [-0.48, 0.58]), indicating a reduction in high frequency activity and potential attentional resources (Tarrant et al., 2018). Summary statistics and effect estimates for pre-post effects for each condition are provided in Supplementary Materials, Table S3. Furthermore, Beta activity reduced in the Anterior Cingulate Cortex following the mindfulness exercise ($p = .048$) but not the open eyes resting period ($p = .998$), with a large effect size ($g = 1.87$, 95%*CI* [0.97, 2.78]). Summary statistics and effect estimates are presented in Supplementary Materials, Table S2.

10.4.5. Mediators of reductions in state anxiety

McEvoy et al. (2017) examined mediators of the relationship between intervention condition and state cognitive anxiety. The predictor variable was intervention condition. Given the authors found similar reductions in anxiety following both a mindful PMR exercise and an attention training technique, the two interventions were combined and compared to a non-therapeutic control (thought wandering). Compared to the control group, the two interventions were associated with higher levels of present-focused attention and ability to distance from thoughts and feelings (distancing), and lower perceived uncontrollability of thoughts, and these were associated with lower state cognitive anxiety at post-intervention. In contrast, Stroop accuracy was not found to significantly mediate the relationship between intervention condition and state cognitive anxiety. Effect estimates of indirect effects for mediation analyses are presented in Supplementary Materials, Table S4.

10.4.6. Predictors of gains in attention

Tarrant et al. (2018) examined correlations between anxiety symptoms and EEG activity. Generalised anxiety symptoms were negatively associated with Alpha power at both pre- ($r = -.35$, $p = .080$) and post-induction ($r = -0.43$, $p = .027$) (averaged across both a mindfulness exercise and an open eyes resting control). Furthermore, generalised anxiety symptoms were also negatively associated with the ratio of Low Beta to High Beta at both pre- ($r = -0.43$, $p = .030$) and post-induction ($r = -0.39$, $p = .048$). Pre-post difference scores for state anxiety were positively associated with pre-post difference scores for High Beta power ($r = 0.46$, $p = .019$). Effect estimates for correlational findings are presented in Supplementary Materials, Table S5.

10.5. Certainty assessment

Results for the assessment of certainty of the evidence for each outcome using the GRADE rating tool are presented in Table 4, with explanations for judgements provided in footnotes. Across outcomes, certainty of evidence was largely rated as 'Low' to 'Very Low'. Evidence was largely downgraded for Risk of Bias and Indirectness, including a lack of samples defined by a clinical diagnosis of GAD. While publication bias was not statistically examined due to a small number of included studies, it was not strongly suspected as we utilised a comprehensive search and found both negative and positive trials.

11. Discussion

We first aimed to review the effect of acute mindfulness induction on state anxiety and attention, and where available, state mindfulness and distress. Five studies met our eligibility criteria. After exclusion of one outlier, pooling of three studies revealed that mindfulness induction exercises had a medium effect on state anxiety ($g = 0.60$), when compared to non-therapeutic controls. Two studies assessed the effect of mindfulness induction compared to therapeutic active controls on state anxiety (small and moderate effects) but were not pooled in a meta-analysis. One study included a measure of state distress (negative affect) (Xu et al., 2017) and found a reduction with small effect in favour of mindfulness induction. Overall, the certainty of evidence for state anxiety and distress was low and very low, respectively. However, our results appear consistent with previous reviews that have found small effects for both brief mindfulness interventions (Schumer et al., 2018) and single session yoga (Yin et al., 2021) on measures of negative affect and state anxiety, respectively. The present findings appear inconsistent with a more recent trial showing no difference between mindfulness induction and control (e.g., relaxation induction) on state anxiety and negative affect (Nien et al., 2023). As these reviews and trials have predominantly included non-clinical samples, the current review extends on these findings to demonstrate reductions in state distress and anxiety following mindfulness induction in those experiencing anxiety symptoms, and thus a propensity to accessing a mood state characterised by worry, tension, and nervousness (APA, 2013).

Three studies compared mindfulness induction to non-therapeutic active controls on attention measures. However, findings could not be pooled. From two of these studies, gains due to mindfulness induction were not observed on tasks measuring aspects of sustained attention (Xu et al., 2017) or executive control (McEvoy et al., 2017). Previous findings of the effect of mindfulness training interventions on behavioural measures of attention have been largely mixed (e.g., Chiesa et al., 2011; Lao et al., 2016; Yakobi et al., 2021). In a meta-analysis comparing mindfulness induction to active control, Gill et al. (2020) found no effects for attention or executive functioning, while more recent trials have found effects for inhibition and task shifting following mindfulness induction, yet mixed effects for sustained attention (Somaraju et al., 2023; Ueberholz and Fiocco, 2022; Vieth and Von Stockhausen, 2022). Thus, while limited, current behavioural findings in anxious individuals appear consistent with previous findings from non-clinical populations for sustained attention, but somewhat inconsistent for executive control. Norris et al. (2018) found those with low (but not high) levels of neuroticism showed gains in top-down attention, as indexed by both reaction times and Event-Related Potentials (ERPs), following 10-min induction. Detriments in allocation of attention have been observed behaviourally in individuals with high relative to low levels of anxiety in general (e.g., Qi et al., 2014; Yu et al., 2018), as well as in response to threat-specific information (i.e., attentional bias to threat) (see Bar-Haim et al., 2007). Such findings support the idea that anxiety impairs attentional control and cognitive performance (Eysenck et al., 2007). To fully understand the way in which these detriments are impacted, if at all, following acute mindfulness induction, further high quality RCTs are needed that compare differences in attention outcomes between healthy and high anxiety/anxiety disorder samples, using both neutral and threat-related stimuli.

One study in the current review examined EEG measures (Tarrant et al., 2018). This study found an increase in Low Beta to High Beta ratio and a reduction in Beta activity in the Anterior Cingulate Cortex (ACC; involved in attentional functions and worry) following mindfulness induction but not active control, with small and large effects, respectively (Tarrant et al., 2018). This is consistent with previous findings indicating mindfulness is associated with increased alpha and theta band activity (Lomas et al., 2015) and that higher beta activity is related to poorer attention (Palacios-García et al., 2021), suggesting that mindfulness works to lower the frequency of brain activity. While the present finding is inconsistent with work showing that mindfulness-based induction combined with exercise is linked to greater beta activity in frontal regions, the use of a healthy sample and inclusion of exercise and associated arousal may explain this difference (Bigliassi et al., 2022). Furthermore, in line with previous work, neuroimaging techniques have also consistency identified effects of mindfulness in the ACC among healthy participants, either following mindfulness training or in experienced meditators (Ganesan et al., 2022; Zsadanyi et al., 2021). While limited, findings in the current review suggest that low frequency activity in the ACC may be an important marker of skill development, even at acute stages of mindfulness practice, in anxious individuals, and that

Table 4
Summary of Findings Table using the GRADE Rating System.

Certainty assessment									Summary of findings			
Outcome	Number of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Mindfulness intervention *n*	Control *n*	Relative effect (95% CI)	Absolute effect (95% CI)
Mindfulness induction vs. non-therapeutic control												
State anxiety	3	RCT (Except Tarrant et al., 2018)	Serious[a]	Not serious[b]	Serious[c]	Not serious[d]	Not suspected[e]	⊕⊕◯◯ LOW	52	48	–	SMD[r] **0.60 lower** (1.04 lower to 0.16 lower)
State mindfulness	2	RCT	Very serious[f]	Not serious[g]	Serious[c]	Not serious[d]	Not suspected[e]	⊕◯◯◯ VERY LOW	56	54	–	SMD[r] **0.91 higher** (0.52 higher to 1.30 higher)
State distress	1	RCT	Very serious[f]	N/A[h]	Serious[c]	Not Serious[i]	N/A[j]	⊕◯◯◯ VERY LOW	42	40	–	*g*[s] **0.29 lower** (0.72 lower to 0.14 higher)
Attention	3	RCT (Except Tarrant et al., 2018)	Serious[k]	Not serious[l]	Serious[c]	Serious[m]	Not suspected[e]	⊕◯◯◯ VERY LOW	81	78	–	Not estimable. One study found significant mindfulness gains. Two studies did not.
Mindfulness induction vs. therapeutic active control												
State anxiety	2	RCT	Serious[n]	Serious[o]	Serious[c]	Serious[m]	Not suspected[e]	⊕◯◯◯ VERY LOW	41	41	–	Not estimable. One study found significant mindfulness gains. The other did not.
State mindfulness	2	RCT	Serious[n]	Serious[o]	Serious[c]	Serious[m]	Not suspected[e]	⊕◯◯◯ VERY LOW	41	41	–	Not estimable. Neither study found significant mindfulness gains.
Attention	1	RCT	Not Serious[p]	N/A[h]	Serious[c]	Not serious[q]	N/A[j]	⊕⊕⊕◯ MODERATE	25	27	–	Not estimable. Study did not find significant mindfulness gains.

[a] Evidence was downgraded by 1 level because the overall risk of bias was rated as high in one study and there were some concerns in all studies, mainly due to issues with missing outcome data and selection of the reported results.
[b] Evidence was not downgraded as heterogeneity was $p > .001$ and $I^2 < 50\%$ after the removal of an outlier from the meta-analysis.
[c] Evidence was downgraded by 1 level as there was not the availability of samples defined by a clinical diagnosis of GAD.
[d] Pooled sample size meets power estimate and CI not found to be wide (i.e., upper or lower limit do not cross SMD of 0.5 in either direction).
[e] Publication bias was not strongly suspected as a comprehensive search was utilised and both negative and positive trials were found.
[f] Evidence was downgraded by 2 levels because the overall risk of bias was rated as high in both studies, mainly due to issues with deviations from the intended interventions, missing outcome data and selection of the reported results.
[g] Evidence was not downgraded as heterogeneity was $p > .001$ and $I^2 < 50\%$ after the removal of an outlier from the meta-analysis.
[h] Only one study is available for this outcome and therefore inconsistencies cannot be considered.
[i] Sample size meets power estimate and calculated CI for *g* not found to be wide (i.e., upper or lower limit do not cross *g* of 0.5 in either direction).
[j] Cannot be assessed due to availability of only 1 study.
[k] Evidence was downgraded by 1 level because the overall risk of bias was rated as high in one study and there were some concerns in the other two studies, mainly due to missing outcome data and selection of the reported results.
[l] Evidence was not downgraded as similarity in results were found for the two studies with behavioural findings. The study that found significant increases measured attention using resting state EEG.
[m] Sample size for one study did not meet power estimate and CI for *g* was found to be wide (i.e., upper or lower limit crossed *g* of 0.5 in both directions) in another study.
[n] Evidence was downgraded by 1 level because the overall risk of bias was rated as high in one study and there were some concerns in the other, mainly due to issues with missing outcome data, deviations from the intended intervention and selection of the reported results.
[o] The statistical significance and magnitude of the effect differed for the two studies.
[p] Evidence not downgraded. Some concerns for Risk of Bias, however, potential limitations related to selection of the reported result are unlikely as null findings were published for this outcome.
[q] Sample size meets power estimate and calculated CI for *g* found to be wide (i.e., upper or lower limit cross *g* of 0.5 in either direction) for only 2/8 within group effects.
[r] SMD is the pooled estimate derived from the meta-analysis.
[s] g is derived from calculations using data available in the study article.

the attentional effects of acute induction may be more observable at the neural rather than behavioural level. However, it is important to note that the certainty of evidence for attention measures overall was moderate to very low. There is a need for more RCTs examining the effect of mindfulness on attentional mechanisms in individuals experiencing anxiety. Inclusion of electrophysiological (e.g., ERPs) measures would help to delineate potential effects non-observable through behavioural measures alone.

After exclusion of one outlier, pooling of two studies revealed that mindfulness induction exercises had a large effect on state mindfulness ($g = 0.91$) when compared to non-therapeutic active controls. Two studies also assessed the effect of mindfulness induction compared to therapeutic active control on state mindfulness but were not pooled in a meta-analysis. These studies found negligible-small effects in favour of the mindfulness condition. A previous review found that self-reported trait mindfulness increased following multi-session mindfulness training programs with moderate effect, as well as following active controls and waitlist (but not treatment as usual) with small effect (Tran et al., 2022). Including various measures (i.e., self-report, behavioural, electrophysiological and neuroimaging), Feruglio et al. (2021) found reductions in mind wandering (task/stimulus unrelated thinking) following mindfulness training. The current results extend on these previous findings from non-specified samples to show similar effects on state mindfulness following acute induction in samples with high anxiety. However, there is still debate on how to conceptually define and measure mindfulness as a construct (Tran et al., 2022) and further RCTs using a range of measures (e.g., behavioural, neuroimaging, and electrophysiological) are needed to discern the specific mechanisms involved in mindfulness gains in high anxiety participants.

It is important to note that the final meta-analyses for state anxiety and mindfulness were reported with the removal of a repeated outlier (i.e., McEvoy et al., 2017). It is possible the addition of a progressive muscle relaxation component in this study produced an interactive effect, yielding stronger gains. Previous work has suggested relaxation interventions are effective for GAD symptom reduction, with the thought that they work by reducing hyper-arousal related to sympathetic nervous system activation (Hayes-Skelton et al., 2013). Future research may seek to further investigate the interactive effects of relaxation and mindfulness induction exercises on state outcome measures among anxious individuals.

The second aim of the current review was to identify the impact of any predictors, mediators or moderators of post-mindfulness induction changes in state anxiety and attention in high anxiety individuals. One included study found increased self-reported present-focused attention and distancing from thoughts and feelings, and reduced self-reported perceived uncontrollability of thoughts, mediated the relationship between assignment to a mindfulness or attention training exercise and reduced state cognitive anxiety (McEvoy et al., 2017). However, accuracy on the Stroop task did not mediate the relationship. This finding is consistent with previous reviews identifying measures of trait mindfulness as mediators of anxiety reduction following mindfulness training interventions (Alsubaie et al., 2017; Gu et al., 2015; Johannsen et al., 2022). Mindfulness meditation training is thought to improve self-regulation through the processes of attentional control, emotional regulation, and self-awareness (Hölzel et al., 2011; Tang et al., 2015). Possibly, repeated activation of these mechanisms across ongoing training is needed to develop less effortful self-regulation to aid symptom reduction (see Hölzel et al., 2011; Tang et al., 2015). This may be supported by the fact that we observed a large effect of mindfulness induction on state mindfulness as compared to state anxiety where a moderate effect was found, suggesting that, at least at early stages of training, a mindful state may be more achievable than reduced anxiety following single session induction.

There are several limitations of the current body of evidence. We identified few eligible studies, and several contained small sample sizes, potentially leading to imprecise estimates and findings of limited generalisability to the broader population. Furthermore, a high risk of bias was noted across studies. This was largely due to 'deviations from the intended interventions' and 'missing outcome data'. Such limitations contributed to the overall low to very low certainty in evidence ratings for the majority of outcomes. Future studies should seek to to perform adequate intention-to-treat analyses, aim to recruit larger samples, and interpret findings in accordance with limitations (e.g., small sample size, issues of missing data). A further limitation is the lack of information reported regarding past/current meditation experience, as such pre-existing characteristics pose a potential threat to internal validity. We also acknowledge that only one review member extracted data and assessed Risk of Bias and certainty of evidence. While a senior review author assessed the plausibility of decisions where required, we have introduced some risk of error. However, we are confident that this limitation would not change our overall conclusions. A further limitation is that some missing data could not be obtained and was therefore imputed using other available statistics. It is possible that the imputed data lack precision, resulting in over/under-estimations of effects. Grey literature was not included in this review and we also utilised a stringent screening criteria, such that studies needed to have both a pre-post outcome and a control group. While these are strengths of our method which enhance our confidence in causality and the robustness of findings, we have likely restricted other, less rigorous, but potentially relevant studies. Future research could address these limitations in reviews with more lenient criteria. For example, objective 2 could be addressed by allowing studies reporting only post-intervention outcomes and without a control group.

Findings from the current review indicate that brief mindfulness induction exercises reduce state anxiety and increase state mindfulness in individuals experiencing anxiety when compared to non-therapeutic exercises. Additionally, aspects of state mindfulness may be important mediators of reductions in state anxiety. The findings are of value to both healthcare providers and consumers. Mindfulness meditation apps have become widely available and show small-medium effects in reducing anxiety symptoms (Gál et al., 2021), offering individuals access to brief induction exercises. However, the confidence intervals for the effect of state anxiety in the current review indicate that little to no anxiety reduction may be experienced. In contrast, confidence intervals for the effect of state mindfulness indicate that at least an increase of moderate effect might be expected. This may be an important message for individuals impacted by anxiety, as the experience of state mindfulness may not be reliably accompanied by the desired immediate removal of anxiety (as needed for negative reinforcement), which could act as a barrier to ongoing engagement. For example, open-ended and semi-structured interviewing research has identified perceived lack of time, limited knowledge, negative perceptions, and strong negative emotions as key barriers to mindfulness practice (Gryffin et al., 2014; Laurie and Blandford, 2016). Further, repeated activation of state mindfulness may be particularly important for the development of self-regulatory skills associated with symptom reduction across time (Cheung and Ng, 2019; Lundwall et al., 2019). Future high quality RCTs addressing current issues of risk of bias and low certainty of evidence, and comparing mindfulness induction to other therapeutic exercises in clinically defined high anxiety samples are needed to further inform practice, particularly given the issues of inconsistency of effects, and absence of samples defined by a clinical diagnosis of GAD. For example, similar effects for mindfulness and other techniques (e.g., CBT, relaxation) might suggest providing individuals with a menu of options is more beneficial than simply recommending mindfulness.

The current review sought to identify 1) the effect of acute mindfulness induction on state anxiety and attention among individuals with high anxiety and 2) the impact of any predictors, mediators and moderators of these effects. Our findings suggest that brief mindfulness induction exercises reduce state anxiety and distress with moderate and small effects, respectively, and increase state mindfulness with large effect, when compared to non-therapeutic exercises. Our narrative

review suggests limited support for behaviourally measured attentional gains in anxious individuals, but further research is needed on this topic. While we found limited evidence of predictors, mediators or moderators of outcomes, the current literature suggests that facets of state mindfulness may be important for anxiety reduction following mindfulness induction. However, further high quality RCTs are needed to obtain robust and generalisable findings regarding the effectiveness of mindfulness induction for symptoms of anxiety, including trials with clinical samples, both subjective and objective measures, and therapeutic controls. Such work is critical to our developing knowledge of how accessible mindfulness exercises can be suitably presented and tailored to those experiencing debilitating and costly symptoms of anxiety.

Authorship contribution statement

The protocol was developed by Monique Williams and Dr Matthews. The search strategy was developed in consultation with a research librarian at the University of Tasmania. Monique Williams undertook all screening, extraction, risk of bias and certainty of evidence assessments, statistical analyses and narrative review, and interpretation of results. Sarah Skromanis and Ben Sanderson shared independent screening of articles and equally contributed. Dr Matthews also contributed to independent screening of articles. Dr Matthews and Dr Honan have provided methodological input and contributed to the manuscript. All authors have reviewed and approved of the final version of the manuscript.

Registration and protocol

This systematic review/meta-analysis has been registered in the international prospective register of systematic reviews (PROSPERO) under the registration number: CRD42021222389. A protocol relating to the current review as part of a broader review was developed and will be provided to researchers upon reasonable request to the corresponding author. After the review commenced, some amendments were made to the protocol, which can be viewed on the PROSPERO registration.

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Data availability statement

Materials, including extracted data from included studies, data used for analyses, analytic code, and other materials used in the review will be provided to researchers upon reasonable request to the corresponding author.

Declaration of competing interest

The authors have no competing interests to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2023.12.009.

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